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GLASSIONOMER CEMENT FOR PERMANENT DENTAL RESTORATIONS: A 48-MONTHS, MULTI-CENTRE, PROSPECTIVE CLINICAL TRIAL

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Abstract

Aim: Glassionomer cements (GICs) have been used for many years as restorative materials, as luting cements or as temporary fillings. The aim of this study was to evaluate the clinical performances of a glassionomer-based restorative system for Class I, II and V permanent dental restorations.
Methodology: 4 experienced operators performed 380 dental restorations using a resin-coated high-viscosity GIC (Equia Fil and Equia Coat, GC, Europe NV, Belgium). Both vital and non-vital teeth were included and the use of dental dam was registered to identify possible differences in survival rate. Follow-up was scheduled at 3, 6, 12, 18, 24, 36 and 48 months, during which restorations were assessed for survival, partial loss or failure, changes in color, texture and integrity of surface and margins.
Results: 304 restorations in 202 patients were still included in the study and evaluated after 48 months: 82 class I, 150 class II and 72 class V. Twenty-six restorations out of 304 were lost, broken or seriously altered. They were considered as "failures", defining a General Success Rate (GSR) of 91,45%. Thirty-six restorations presented a damage of less than 1 mm at the marginal edge, and they were considered as "successful". The General Integrity Rate (GIR) was 79,61%. No statistical differences were identified for using the glassionomer restorative material in vital or non-vital teeth, or using or not a dental dam.
Conclusions: A restorative system based on a high-viscosity glassionomer cement coated with an acrylic light-cured resin showed excellent behavior in the medium-long term.

Keywords: glassionomer cements, bioactive materials, minimally invasive dentistry, fluoride.

Introduction

Glassionomer cements (GICs) were introduced in dentistry in the mid-seventies (1). They have a number of significant properties, such as the creation of a chemical bond with enamel and dentin collagen, a coefficient of thermal expansion almost equal to that of dental tissues and, most importantly, the ability to release fluoride ions over a significant amount of time (2,3). The clinical advantage of these dental materials includes the ability to prevent (4-6) and inactivate (7-9) dental caries and its progression. These characteristics have been widely described in literature, placing them in the group of bioactive materials. However, even if GICs available nowadays can show a satisfying resistance to compression (equal to about 30 MPa), the oldest formulations of GICs had limited success because of their poor resistance to abrasion, low tensile strength and low final hardness (10,11). For this reason, in the '70s and early '80s their use as restorative materials was limited to small and medium size cavities and especially for cervical restorations and sealing. For bigger restorations, amalgam was still the first choice.
In the '80s, with the improvement of composite resins, the use of GICs for dental restorations gradually decreased

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Figure 1 A mesio-occlusal class II composite restoration is shown in an upper right first molar. The restoration margins present chippings and the restoration itself is not functional

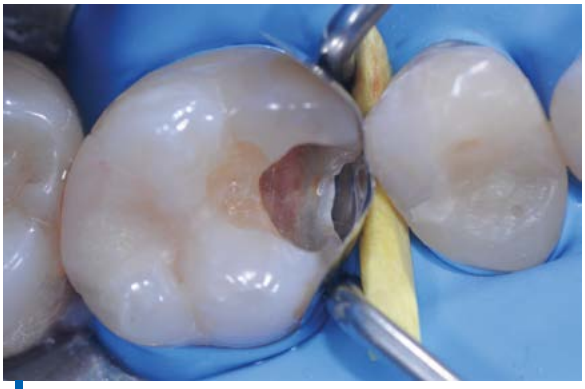

Figure 2 The situation is shown after positioning of the rubber dam, cleaning the cavity and positioning of a curved partial matrix execution of retentive walls, bevels, notches, or unnecessary removal of healthy tooth tissue

Figure 3 The restoration after application of high-viscosity GIC. The removal of the matrix was performed after 3 min. from mixing time to ensure the initial hardening of the material

Figure 4 The completed restoration after rubber dam removal, occlusal check, finishing and application of the resin coating. The coating confers the "glossy" appearance to the restoration. Good marginal adaptation and overall acceptable aesthetics of the restoration can be recognized

due to a poor level of marginal sealing and a relatively low resistance to wear (12). Glassionomer cements for dental restorations also acquired the label of cheap materials, not of high quality, especially useful for rapid restoration, and more focussed on social assistance, becoming the material of choice for Atraumatic Restorative Dentistry (ART) (14-16). Recently, the introduction of nanotechnology in dentistry allowed for significant structural changes in many dental materials, from impression materials (17) to resin composites (18,19), and in particular also for glassionomer cements (17,19). In particular, the limits of hardness and resistance to stress of GICs have been significantly improved, and modern GICs can also give an aspect of natural translucency and coloration to restorations, representing a valid aesthetic solution (20, 21).

Moreover, manufacturers improved fluoride release from modern GICs in order to increase their role in the treatment and prevention of caries. As a consequence, recent studies identified high concentrations of fluoride and other ions in the dentine adjacent to GICs restorations (2,3). It was also demonstrated that, by ion release, GICs can strongly remineralise the demineralized dentine when a layer of material is placed directly on the affected dentinal surface (22).

Considering the evolution of GICs and their role as bioactive materials, the aim of this study was to evaluate the durability and possible issues of a novel GIC system based on a high-viscosity glassionomer cement coated with a light-curable resin based on nanotechnology, when used for long-term teeth restorations.

Methodology

Patients visited at the Dental Clinic of the IRCCS Galeazzi Orthopedic Institute (Milan, Italy) from 2007 to 2010 who required dental restorations

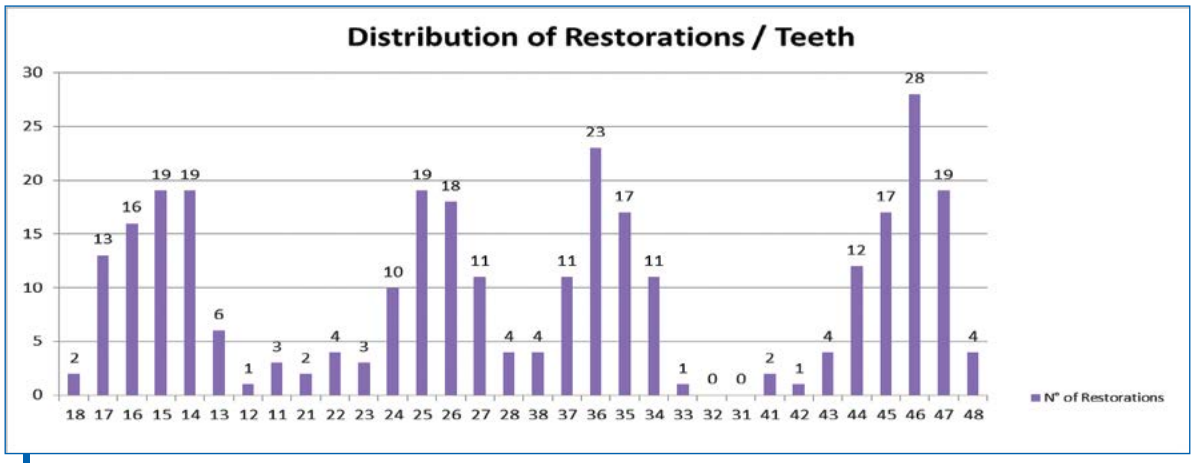

Figure 5 Distribution of restorations at 48 months, in dependence of the restored tooth number

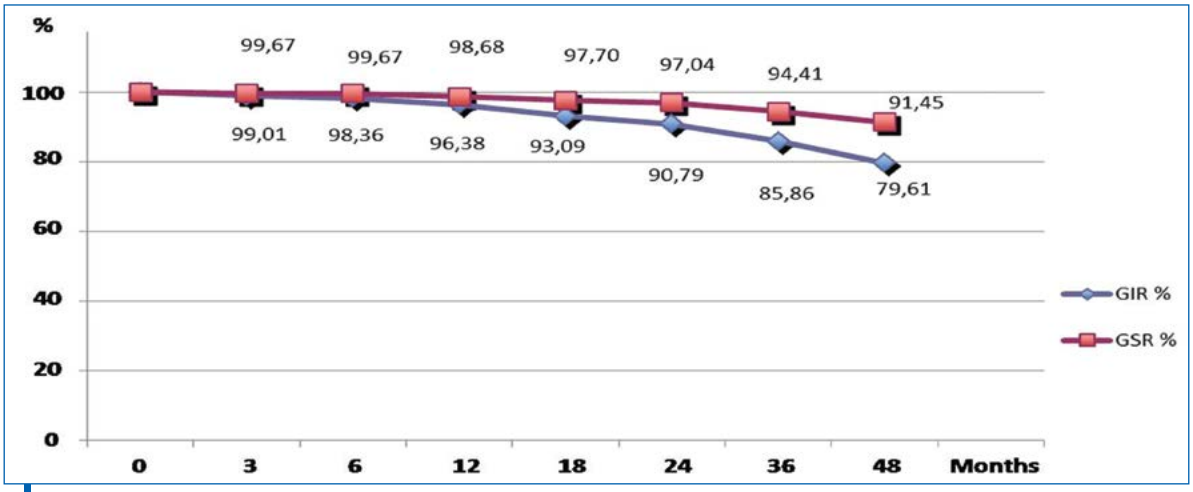

Figure 6 General Success rate (GSR, Frencken's Code ≤ 3) and General Integrity Rate (GIR, Frencken's Code = 0) for all restorations at the different follow-up times

belonging to Black's Class I, II or V were enrolled for this clinical trial. Patients were treated according to the Helsinki declaration regarding clinical trials. The inclusion and exclusion criteria are listed in Table 1.

A total of four dentists (more than 5 years dental clinical experience in restorative dentistry after graduation) were selected as operators. They were first instructed on the correct use of tested restorative material and the trial protocol. The restorative material was a high-viscosity glassionomer cement, coated with a light-curable acrylic resin used as protective and reinforcing agent (Equia Fil® and Equia Coat®, both from GC Europe NV, Belgium).

The protocol used for performing restorations was the following, as described in Figures 1-4:

1. Placement of the dental dam (Fig. 2), whenever possible and in any case when old amalgam fillings removal was required. The use or not of dental dam has been recorded for statistical analysis.
2. Preparation of the cavity, without the execution of retentive walls, bevels, notches, or removing healthy tooth tissue. The tooth preparation for the use of glassionomer cements was made with the same criteria normally used for resin composites (Fig. 2).
3. According to the manufacturer's instructions, describing it as "not mandatory", and to simplify the procedures, the use of dentin conditioner was excluded. Capsules were prepared and mixed for 10 seconds, then the material was directly applied into the prepared cavity in a sufficient quantity. Where necessary the material was compacted with a manual condenser. A total of 3 minute-waiting time was allowed after mixing for complete hardening of the material (Fig.3).
4. The finishing process was performed with the use of hand and rotary instruments in three steps: a) coarse diamond burs; b) Brownie polisher (Shofu, Kyoto, Japan); c) Greenie polisher (Shofu). All burs and polishers were used under water irrigation to avoid overdrying the material.
5. The occlusal points of contact were checked.
6. A final layer of the coating agent was applied on all the surfaces of the restoration, then it was light-cured for 20 s at 800mW/cm^2 using a portable hand-held light curing unit (Fig. 4).
7. Relieve the patient, taking care that he does not bite hard on the new restoration for the first few hours.

Table 1 Inclusion and exclusion criteria for patients enlisted in the present trial

	Inclusion criteria	Exclusion criteria
1	Healthy patients, without particular pathologies that could affect clinical results;	Patients under pregnancy, lactation, oncologic patients, alcohol addicted, with infectious pathologies or patients reporting allergies to the specific components of the dental products used in the trial; patients presenting local or systemic diseases affecting saliva production or quality; heavy smokers (>15 cigarettes/day)
2	Good oral hygiene (Full-mouth plaque score, FMPS < 20%)	Poor oral hygiene (FMPS > 20%)
3	Presence of natural antagonist. Presence of composite or already existing glassionomer restorations in the antagonist tooth was tolerated. No restorations on antagonist teeth were involved in the trial	Not functioning teeth (teeth without antagonists)
4	Absence of prosthetic antagonist (any material)	Teeth with a prosthetic antagonist (any material)
5	For Class I and II: cavities deeper than 2 mm, involving both enamel and dentin	Cavities less than 2 mm deep or cavities limited to enamel layer
6	For class II: cavities with 2, 3, 4, 5 walls in permanent teeth were accepted	Deciduous teeth, since the use on deciduous teeth is not recommended by manufacturer of tested product
7	Both vital or non-vital teeth. Parameter of vitality was recorded for statistical analysis	Dental students or dental practitioners. According to FDI recommendations (23), they are not representative of a real community since they possess different dental awareness
8		Bruxism
9		Patients declaring daily consumption of chewing-gums. Consumption of chewing-gums, and their brands and frequency of assumption were checked at each follow-up.

Table 2 Criteria used to assess the overall success of restorations during follow-up examination

Code	Criterion	Definition
0	Present, satisfactory	Successful
1	Present, slight defect of cavity margin <0,5 mm	Successful
2	Present, marginal and/or edge chipping <1 mm	Successful
3	Present, marginal defect deeper than 0.5 mm	Failed
4	Partially present, restoration and/or tooth breakdown	Failed
5	Not present, restoration missing	Failed
6	Not present, other restorative treatment performed	Failed
7	Not present, tooth has been extracted	Failed
8	Pulpal involvment	Failed
C	Caries present	Failed

Table 3 Distribution of restorations evaluated after 48 months according to cavity class and number of restored surfaces

Class	N. of surfaces	Incisors	Canines	Premolars	Molars
I	1			23	59
II	2			28	30
	3			19	24
	4+			18	31
V	1	13	14	36	9
Total: 304 (100%)		13 (4.28%)	14 (4.61%)	124 (40.79%)	153 (50.33%)

Table 4 Relationship between type of restoration and incidence of success, chipping or loss

Class	Integral (code 0)	Chipped (codes 1, 2)	Total success	Partial Lost (codes 3, 4)	Failures (code ≥ 5)	Total failures
Class I	77 (93,9%w)	4 (4,88%)	81 (98,78%)	0 (0%)	1 (1,22%)	1 (1,22%)
Class II	116 (77,33%)	19 (12,67%)	135 (90%)	4 (2,67%)	11 (7,33%)	15 (10%)
Class V	49 (68,05%)	13 (18,06%)	62 (86,11%)	0 (0%)	10 (13,89%)	10 (13,89%)
Total	242 (79,61%)	36 (11,84%)	278 (91,45%)	4 (1,32%)	22 (7,24%)	26 (8,55%)

The four operators were first allowed to place and photograph 10 restorations each, according to the protocol. Then, joint meetings of all the operators were organised in order to discuss the photographs and verify the concordance with the use of the tested material and the clinical protocol. Periodic meetings were held during the trial in order to verify that the operators followed the protocol and the material guidelines over time.

From the beginning of 2007 until May, 2010, 380 restorations were performed on 256 patients according to the study protocol. Evaluation of the restorations was performed at 3, 6, 12, 18, 24, 36 and 48 months considering the following parameters: survival, partial loss or failure, changes in color, texture and integrity of surface and margins.

Integrity of the restorations was assessed by visual inspection, identifying the possible breaking of macroscopic portions of the restorations. Inspection was performed using Karl-Zeiss® 3,5xhead-worn magnifying loupes and a sharp probe to check surface integrity, especially at the margins. Dental Floss was used to assess the integrity at contact points.

The overall success of restorations was obtained using the criteria described by Frencken et al. (14) and furtherly modified by Zanata et al. (24) in Table 2. According to those criteria for success, the following parameters were calculated:

- General Success Rate (GSR): percentage of restorations corresponding to codes 0, 1 and 2.
- General Integrity Rate (GIR): percentage of restorations corresponding only to code 0.

During the evaluation period, patients were also given a questionnaire, in which they had to tick several parameters such as side effects, dental sensitivity, allergies, general satisfaction, colour matching, chewing ability. Vitality was tested during every follow-up visit using a cold test, sprayed on a cotton pellet and hold for 5 seconds in contact with the vestibular cervical area.

Statistical analysis was performed by MedCalc Software, version 11.5.1.0 (Medcalc, Mariakerke, Belgium). ANOVA was used to evaluate the influence of the number of walls of restorations or the class of restorations on failure rate. Cox regressive models were applied to evaluate the influence of the different tested parameters on survival rate of restorations.

Results

After 48 months, 304 restorations in 202 patients were still included in the study: 82 class I, 150 class II and 72 class V. Among the 76 drop-outs that occurred in 4 years, 57 were lost because one of the trained experimenter stopped collaboration, 3 because teeth were extracted, and 16 because related patients did not respect the follow-up planning.

The distribution of the restorations evaluated after 48 months is shown in detail in Figure 5 considering the restored tooth number, and in Table 3 considering the cavity class and the number of restored surfaces.

A General Success Rate (GSR) of 91.45% was calculated for the totality of 304 restorations included in the trial at 4 years.

Table 5 Chippings of restorations according to cavity class and number of restoration surfaces (number of chippings / total number of specific restorations)

No. of surfaces	Incisors	Canines	Premolars	Molars
1			1/23 (4,35%)	3/59 (5,08%)
2			1/28 (3,57%)	4/30 (13,33%)
3			0/19 (0%)	3/24 (12,5%)
4+			4/18 (22,22%)	7/31 (22,58%)
Class V	0/13 (0%)	3/14 (21,43%)	7/36 (19,44%)	3/9 (33,33%)
Total Chippings	**0/13 (0%)**	**3/14 (21,43%)**	**13/124 (10,48%)**	**20/153 (13,07%)**

Table 6 Failures of restorations according to cavity class and number of restoration surfaces (number of failures / total number of specific restorations)

No. of surfaces	Incisors	Canines	Premolars	Molars
1			1/23 (4,35%)	0/59 (0%)
2			0/28 (0%)	4/30 (13,33%)
3			1/19 (5,26%)	1/24 (4,17%)
4+			5/18 (27,78)	4/31 (12,9%)
V class	2/13 (15,38%)	3/14 (21,43%)	3/36 (8,33%)	2/9 (22,22%)
Total Failures	**2/13 (15,38%)**	3/14 (21,43%)	10/124 (8,06%)	11/153 (7,19%)

Considering the integrity of restorations (code = 0, Table 1), 36 restorations have been recorded as "chipped" (less than 1 mm of marginal damage, codes 1 or 2). Added to the 26 failed restorations (code > 2), a total of 62 restorations were not considered for the General Integrity Rate (GIR). Overall data for GSR and GIR are presented in Figure 6.

The restorations performed were also evaluated considering their success related to vitality of the restored tooth, and optional use of dental dam (Table 7). There was no statistical difference in failure rate for both parameters of vitality and use of dental dam.

No significant differences were found among the four different trained operators in terms of outcomes, failure rates and chippings of restorations.

There were no reported side effects or allergies against the tested glassionomer cement or light-curing acrylic resin after their application. Patients did not report dentinal hypersensitivity, even after replacement of previous dental amalgams. Analyzing the impressions and opinions reported by patients through the questionnaire, the surface of performed glassionomer restorations has been perceived by patients as "very smooth" at the end of procedures. Many patients reported a strong smell and taste of the coating agent while applying it, due to solvents and to its acrylic nature. Once polymerized, this problem disappeared.

11.88% of patients (24 of 202) declared the presence of rough surfaces on the restorations at 12 months, 22.28% (45 of 202) at 24 months, 25.25% (51 of 202) at 36 months, 30.69% (62 of 202) at 48 months. No rough surfaces were declared to be present at the baseline. In the majority of cases (74.19% 46 patients of 62 declaring rough surfaces), the sensation was referred to class V restorations.

Overall, patients were generally satisfied with the restorations, when they were asked to evaluate them from both a mechanical and a functional point of view. Most of them (84.16%, 170 of 202) declared to be "completely satisfied". Regarding the 15.84% of non-satisfied patients, the problems reported were roughness, failures, presence of marginal stains, chipping and aesthetic aspect of restoration.

No loss in pulp vitality has been recorded during the duration of the study.

Moreover, regarding the color matching, the percentage of completely satisfied patients decreased: 72.28% (146 of 202) thought the color was appropriate, while 27.72% declared the color was not perfect, or wrong. On the dentist side, the questionnaire revealed that dentists were satisfied with the color matching with tooth structures of only 52.63% (160 of 304) of the restorations.

Table 7 Relationship between success rate, incidence of failures, partial loss or chipping and the use of dental dam or tooth vitality

		Total restorations	Integral (code 0)	Chipped (codes 1, 2)	Partial Lost (codes 3, 4)	Failures (code ≥ 5)
Dental dam	Yes	118	91	16	2	9
	No	186	151	20	2	13
Tooth vitality	Yes	181	144	22	3	12
	No	123	98	14	1	10

Discussion

Glassionomer cements underwent deep changes in recent years. The materials have evolved, and the severe limitations that characterized the GICs in the 80s have been exceeded. In this clinical trial, the high percentage of success in class I restorations (close to 100%), together with the easy and quick procedure identified by the followed protocol, identified a high viscosity glassionomer cement as a possible and durable choice for this kind of restorations both in molars and premolars. The possibility of achieving durable Class II restorations with the glassionomer-based restorative system tested in this trial seems to be related to the width of the mesial or distal box. According to some clinical indications, the width of the box should not exceed the half of the intercuspal distance. Many chippings and some failures of the Class II restorations performed during this trial were located in the marginal proximal crest, in wider restorations. Furthermore, there was a tendency in Class II restorations performed in premolar teeth of a higher failure rate occurring with higher number of restoration surfaces.

Class V restorations revealed the lowest survival rate in time, suggesting that in this kind of restoration the performances of the tested GIC system were most challenged. Chemical resistance and self-adhesion define glassionomer cement as reliable material for Class V restorations (25), right where many traditional composite restorations with adhesive systems have high percentages of failure rate. Further prospective trials may be performed to compare the failure rate of a high-viscosity GIC with conventional resin-based composites. The 48-months observations were often accompanied by a certain wear of the restoration, visible with magnifying glasses and which became clinically evident with the loss of translucency. Most of the restorations which developed roughness over time were class V restorations. In the present study, the perception of roughness could probably be related to higher exposure of cervical areas to progressive erosion, caused by daily acidic attack, chewing, tooth brushing, effect of professional mechanical cleaning and, especially in lower incisors and cuspids, progressive deposition of tartar. In occlusal areas, the continuing wearing effect as a consequence of chewing may lead to regular abrasion and to the formation of smoother surfaces than in non-occlusal areas as those where class V restorations are performed. This may explain why the majority of patients referred to roughness on restorations done in cervical areas. Interestingly, the increase in roughness perception seems to occur mainly between the first and the second year after placement. It is still unclear if coating agent should be reapplied or not, to increase the external wear-resistant layer, or if its strengthening and protective role remains unaltered, even if the layer appears modified or reduced.

Patients declaring daily consumption of chewing-gums were excluded from this study, and consumption of chewing-gums, and their brands and frequency of assumption were checked at each follow-up. It was claimed, indeed, that gum chewing may have an abrasive effect on softened tooth structure (26). Since no data are available upon the abrasive effect of gum chewing on permanent GIC restorations, this parameter was excluded from the present study.

The use of dental dam is currently the most effective way to provide isolation of the operative field. It is always recommended for composite restorations placement, since it allows an optimal control of oral fluids and avoids contamination of the cavity and the material during placement procedures. In the present trial, each trained operator was instructed to try and position the dental dam prior to restorative procedures and according to the protocol. If, for any reason, it was not possible to isolate the field using a dental dam, the restoration was placed without this type of isolation. GICs are indeed known to tolerate humidity when used in wet areas (1,13) and therefore do not necessarily require the use of dental dam. In fact, it is not always possible to work under ideal conditions: not all patients tolerate the use of dental dam, like children or psychologically vulnerable individuals where is often impractical the application of this device.

Moreover, it is not easy to apply the dam in children due to the shape of deciduous dental elements or elements sometimes only partially erupted, despite the existence of specially-shaped hooks. In these situations the use of GICs may be of particular interest since nowadays the placement of the dental dam during GICs restoration procedures is considered at risk of leading to material over dry and consequently weaker restorations. Our data do not support any significant influence of dental dam positioning on the success or failure of the GICs restorations, even if it is likely that the limited number of failures at 48 months affected the significance of this analysis.

However, it is not fully identified in literature to date which may be the influence of dental dam positioning on the placement of GIC restorations and its role on the long-term survival of the restorations. Regarding the high-viscosity glassionomer cements, the formulation chosen in this study is that of pre-dosed capsules, to be applied after agitation in a special electric mixer and through the use of an applicator. The pre-dosed capsules help avoid errors in mixing and improper calibration of the proportions between the two components (usually powder and liquid), to be mixed as in the majority of GICs products. In fact, incorrect mixing could affect the mechanical properties of the product, and, for a clinical trial, it could introduce an important bias for final evaluation. The light-curable coating employed is able to infiltrate the surface and the margins of the restoration, and is therefore useful in overcoming the limits of resistance to abrasion and marginal cracks occurrence of older GIC systems. The aim of the coating agent is to form a resin layer, with an average thickness of 35-40 micrometres, which seals and protects both the areas of restoration and the adhesive interface between the restoration and tooth structure.

This is particularly valuable because a discrete frequency of dentine hypersensitivity is normally reported while using composite resins to replace the amalgams. The absence of hypersensitivity recorded in this study by the patients' questionnaires may be related to fluoride release and to the absence of any conditioning treatment before the placement of the glassionomer cement. According to the manufacturer's indications and to the protocol of this study, polyacrylic acid or other kind of dentin conditioning systems were not applied on cavity walls before applying the cement. In this clinical trial, the absence of conditioning seemed not to affect the adhesion and the strength of the link of glassionomer cement with enamel and dentin: even if it is likely that a conditioning phase may improve the adhesion of glassionomers to tooth structures, the adhesion achievable through a control of cavity preparation, of rinsing procedures and the use of a modern GIC system may obtain an adhesive interface with adequate strength and resistance. The need of using conditioners with modern high-viscosity glassionomer cements, however has still to be investigated. Regarding their use, modern glassionomer cements can be applied in one step, without layering technique. The estimated time to complete the restoration with the tested GIC is about 3-5 minutes after tooth preparation. Less recent and some of conventional glassionomer cements sometimes require more than 5 minutes (1,11,13). If we consider the mechanical properties of coated glassionomer cements, infiltration into the surface of GICs and dispersion of nano-filler particles contained in resin coating ensure lasting protection and integrity of margins, increasing both the strength and wear resistance (27,28). In fact, they fill the porosities which inevitably forms on GICs surfaces due to the nature of the material. The fluid coating agent creates a regular surface and allows protection of the margins, equal distribution of mechanical load, and protection during the phases of complete maturation of glassionomers: the typical time for reaching final hardness is 6-7 days. The final treatment with coating resins managed to transform the surface of the restoration into a glossy layer, without further polishing.

In terms of aesthetics, the modern glassionomer cements are able to stand superior optical properties when compared to conventional glassionomer cements. The translucency and aesthetic appearance could in fact be connected with application of the nanofilled resin coat. Nevertheless, the questionnaire revealed that especially dentists were much less satisfied than patients about the color matching with tooth structures of the restorations. The low rate of color matching can depend on dentist's choice at the time of restoration, but also on the optical properties of GICs, still not at the same performance as resin-based composites. The lower rate of color matching in the dentists' questionnaire probably depends on the higher competence and criticism level shown by dental professionals when confronted to patients. Regarding the restoration evaluation system, the criteria first described by Frencken et al. in 1996 were used (14). These criteria have been especially developed to assess GIC restorations, taking into account the material characteristics, as previously discussed, and the issues these materials have raised during the past decades. In this sense, these criteria have been preferred to the USPHS criteria described by Ryge in 1973 (29). USPHS criteria can assess additional information respect to Frencken's criteria, however they have been

designed for restorations performed with any material, not only GIC. It is clear that by doing so the present trial may not be directly comparable with other studies. Another limitation of the present study is the lack of a control material. The trial was nevertheless mainly designed to test the hypothesis that a modern, high-viscosity, coated GIC could be a viable material for permanent restorations under certain conditions. Further prospective clinical trials may be performed in order to assess, under conditions similar to the present trial, which survival rates may have high-viscosity, coated GIC restorations on the long-term when compared to the gold standard of resin-based composite restorations.

Conclusions

According to the results described, a dental restorative system consisting in a high-viscosity glassionomer cement and a lightcurable, nanofilled resin coating appears to represent a viable, fast, aesthetically satisfying alternative for dental restorations in the medium and long term. While resin-based composites remain the reference materials for dental restorations, the new features of durability, handling and aesthetic results can expand the possibility of use of modern high-viscosity glassionomer cements in everyday practice.

Bibliography

1. Mount GJ. Glass-ionomer materials. In: Mount GJ, Hume WR, editors. Preservation and restoration of tooth structure. Sandgate (Qld): Knowledge book and software; 2005.
2. Mukai M, Ikeda M, Yanagihara T, Hara G, Kato K, Nagagaki M, Robinson C. Fluoride uptake in human dentine from glass-ionomer cement in vivo. Arch Oral Biol. 1993;38(12):1093-1098.
3. Skartveit L, Tveit B, Total B, Øvrebø R Raadal M. In vivo fluoride uptake in enamel and Dentin fluoride from containig materials. J Dent Child. 1990;57(2):97-100.
4. Salar DV, Garcia-Godoy F, Flaitz CM, Hicks MJ. Potential inhibition of demineralization in vitro by fluoride-realizing sealants. J Am Dent Assoc. 2007;138: 502-506.
5. Fischman SA, Tinanoff N. The effect of acid and fluoride release on the antimicrobial properties of four glassionomers cements. Pediatr Dent. 1994;16(5):368-370.
6. Seppa L, Torooa-Saarinen E, Luoma H. Effect of different glassionomer on the acid production and electrolyte metrabolism of Streptococcus mutans. Caries Res 1992;26(6):434-438.
7. Ngo HC, Mount G, Mc Intyre J, Tuisuva J, Von Dousse RJ. Chemical exchange between glass-ionomer restorations and residual carious dentine in permanent molars: an in vivo study. J Dent. 2006;34(8):608-613.
8. Ngamine M, Hota T, Torii Y, Irie M, Staninec M, Inoue K. Effect of resin modified glassionomer cements on secondary caries. Am J Dent. 1997;10(4):173-178.
9. Weerheijm KL, De Soete JJ, van Amerongen WE, De Graaffd J. The effect of glass-ionomer cement on carious dentin. An in vivo study. Caries Res. 1993;27(5):417-423.
10. Ngo H, Mount GJ, Peters MC. A study of glass-ionomer cement and its interface with enamel and Dentin Using a low-temperature, high-resolution scanning electron microscopic technique. Quintessence Int. 1997;28(1):63-9.
11. Tyas MJ, Burrow MF. Adhesive restorative materials: A review. Aust Dent J. 2004; 49(3):112-121.
12. Swartz JM, Davis RD, Overton JD. Tensile bond strength of resin-modified glass-ionomer cement to microabraded and silica-coated or tin-plated high noble ceramic alloy. J prosthod. 2000;9(4):195-200.
13. Okada K, Tosaki S, Hirota K, Hume WR. Surface hardness change of restorative filling materials stored in saliva. Dent Mater. 2001;17(1):34-39.
14. Frencken JE, Pilot T, Songpaisan Y, Phantumvanit P. Atraumatic restorative treatment (ART): rationale, technique, and development. J Public Health Dent. 1996;56(3 Spec No):135-140; discussion 161-163.
15. Mjör IA, Gordan VV: A review of atraumatic restorative treatment (ART). Int Dent J. 1999;49(3):127-131.
16. Ewoldsen N, Covey D, Lavin M: The physical and adhesive properties of dental cements used for atraumatic restorative treatment. Spec Care Dent. 1997;17(1):19-24.
17. Ozak ST, Ozkan P. Nanotechnology and dentistry. Eur J Dent. 2013;7(1):145-151.
18. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. J Am Dent Assoc. 2003;134(10):1382-1390.

19. Khurshid Z, Zafar M, Qasim S, Shahab S, Naseem M, Abu Reqaiba A. Advances in Nanotechnology for Restorative Dentistry. Materials 2015;8(2):717-731.
20.Basso M. Teeth restoration using a high-viscosity glass ionomer cement: the Equia system. J Minim Interv Dent. 2011;4(3):74–76.
21. Friedl K, Hiller KA, Friedl KH. Clinical performance of a new glass ionomer based restoration system: A retrospective cohort study. Dent Mater. 2011;27(10):1031-1037.
22. ten Cate JM, van Duinen RN. Hypermineralization of dentinal lesions adjacent to glassionomer cement restorations. J Dent Res. 1995;74(6):1266-1271.
23. Hickel R, Roulet JF, Bayne S, Heintze SD, Mjör IA, Peters M, Rousson V, Randall R, Schmalz G, Tyas M, Vanherle G. Recommendations for conducting controlled clinical studies of dental restorative materials (Science Committee Project 2/98 - FDI World Dental Federation). J Adhes Dent. 2007;9(S1):121-147.
24. Zanata RL, Fagundes TC, Carvalho de Almendra Freitas MC, Pereira Lauris JR, de Lima Navarro MF. Ten-year survival of ART restorations in permanent posterior teeth. Clin Oral Invest. 2011;15(2):265-271.
25. Ngo H, Knight G: Surface protection for exposed root surfaces. Dental Practice. 2006; 17(5): 56-57.
26. Zero DT, Lussi A. Erosion -- chemical and biological factors of importance to the dental practitioner. Int Dent J. 2005;55(4 Suppl 1):285-290.
27. Nicholson JW, Czarnecki B.: Kinetic studies of the effect of varnish on water loss by glass-ionomer cements. Dent Mater. 2007;23(12):1549-1552.
28. Leirskar J, Nordbo H, Mount GJ, Ngo H. The influence of resin coating on the punch shear strength of a high strength auto-cure glassionomer. Dent Mater. 2003;19(2):87-91.
29. Ryge G, Snyder M. Evaluating the clinical Quality of restorations. J Am Dent Assoc. 1973;87(2):369-377.

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Questions

High-viscosity glassionomer cements are ideal for:

- ❑ a. Luting
- ❑ b. Post cementation
- ❑ c. Long-term restorations
- ❑ d. Luting of orthodontic brackets

Glassionomer cements:

- ❑ a. Require a self-etch adhesive
- ❑ b. Require conditioning with hydrofluoric acid
- ❑ c. Are exclusively resin-based composite materials
- ❑ d. Bond spontaneously to enamel and dentin by chemical reaction.

Ideal classes for long term glassionomer restorations are:

- ❑ a. Black's Class I, II and III
- ❑ b. Black's Class I, II and V
- ❑ c. Only Class III
- ❑ d. Black's Class III and IV

Placement of a coating layer on the surface of a glassionomer restoration:

- ❑ a. Helps preventing imbibition of the outer layer, increasing quality of glassionomer maturation.
- ❑ b. Creates a very smooth surface, reducing big waste of time in the polishing phase.
- ❑ c. Contributes to better mechanical properties of restorations.
- ❑ d. All previous answers are correct.